Electron-hadron separation in electromagnetic calorimeters: a comparison

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Purpose

- Identification: scattered electron vs negatively charged hadrons in DIS
- Tracker
- Electromagnetic calorimeter

$$\Downarrow$$
$$E/p$$

Purpose

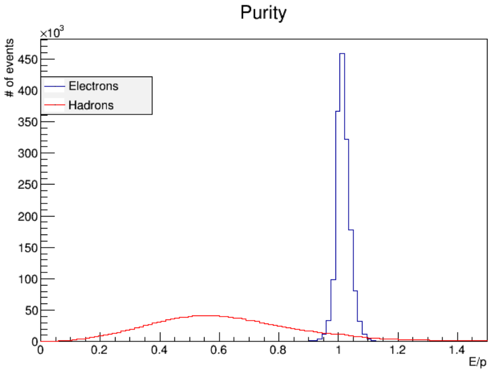

Figure 1 : Lead glass calorimeter, $15\,GeV \; x \; 250\,GeV$

Technical details

- PEPSI e-p polarised in parallel $15\,GeV \, x \, 250\,GeV$
- Calorimeter smearing models for electromagnetic particles:
  - Lead-tungstate: $\begin{cases} \Delta E/E = 0.69\% + 1.78\%/\sqrt{E}\,(\eta < -2) \\ \text{Tungsten powder performance}\,(\eta > -2) \end{cases}$
  - Lead glass: $\begin{cases} \Delta E/E = 0.76\% + 5.95\%/\sqrt{E} & (\eta < -1) \\ \text{Tungsten powder performance} & (\eta > -1) \end{cases}$
  - Tungsten powder: $\Delta E/E = 1.4\% + 9.7\%/\sqrt{E}$
- Calorimeter smearing model for hadrons:

$$\mu/E = 40\% \quad \sigma/E = 10\%$$

Technical details

Momentum resolution

$\|\eta\|$	$\Delta p/p$
$[0.00, 0.25]$	$0.69\%/p + 0.14\% + 0.041\%p$
$[0.25, 0.75]$	$0.49\%/p + 0.21\% + 0.030\%p$
$[0.75, 1.25]$	$-0.013\%/p + 0.40\% + 0.014\%p$
$[1.25, 1.75]$	$0.38\%/p + 0.68\% + 0.016\%p$
$[1.75, 2.25]$	$0.22\%/p + 0.61\% + 0.020\%p$
$[2.25, 2.75]$	$0.82\%/p + 0.79\% + 0.019\%p$
$[2.75, 3.00]$	$2.0\%/p + 1.2\% + 0.061\%p$

Kynematics

- How are electrons and negatively charged hadrons distributed in momentum space?
- Which rapidities are interesting?

Kynematics
Momentum distribution

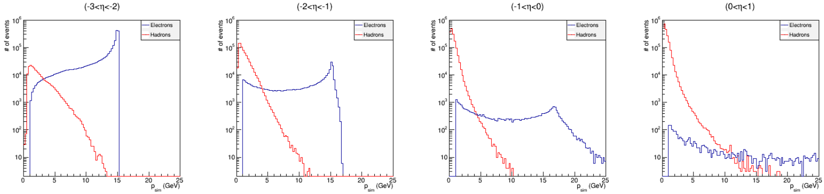

Figure 2 : Electron and negative hadron distribution in momentum space

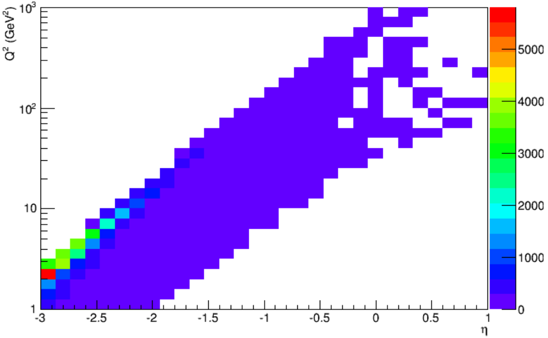

Figure 3 : Q^2 vs η of the scattered electron

- Purity $\equiv 1 - \dfrac{\# had}{\# scat.\, e^{-}} \quad (\pm 3\sigma)$
- σ for scattered electron E/p
- Momentum dependance
- Rapidity bins

Results

General results: purity

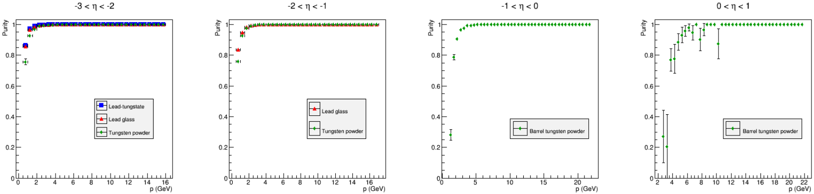

Figure 4 : Purity comparison ($\pm 3\sigma$)

Results

General results: width for the electron signal

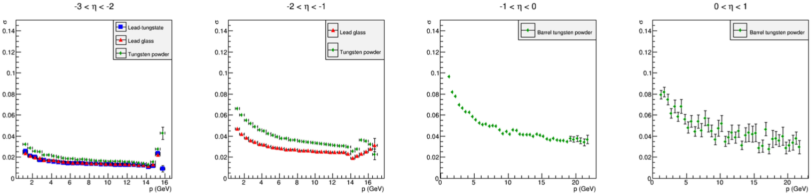

Figure 5 : σ comparison for the electron signal

- Graphical visualization
- Overlap
- Momentum and rapidity bins

Results

General results: graphical visualization

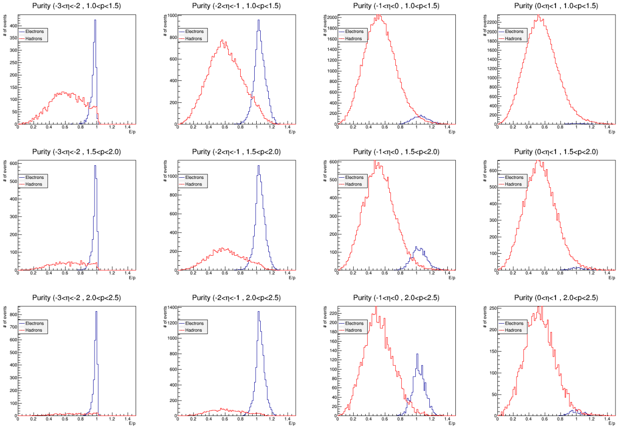

Figure 6 : Overlap for different p and η bins (tungsten powder)

- Alternative to $\pm 3\sigma$, fixed left cut $\Rightarrow$ error
- Efficiency $\equiv 1 - \dfrac{\# scat.\ e^-}{total\ scat.\ e^-}$

Results
Particular results: 0.7 cut

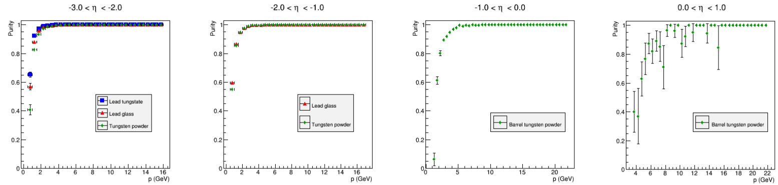

Figure 7 : Purity for a cut at $E/p = 0.7$

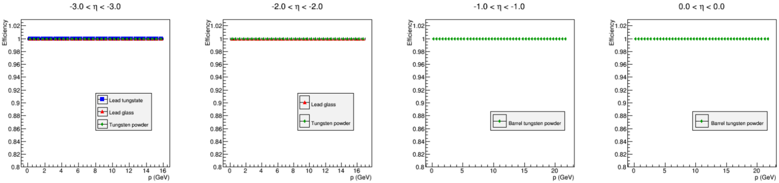

Figure 8 : Efficiency for a cut at $E/p = 0.7$

Results

Particular results: 0.8 cut

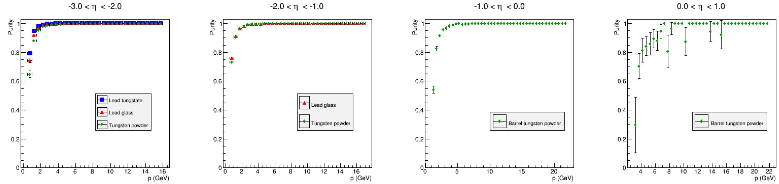

Figure 9 : Purity for a cut at $E/p = 0.8$

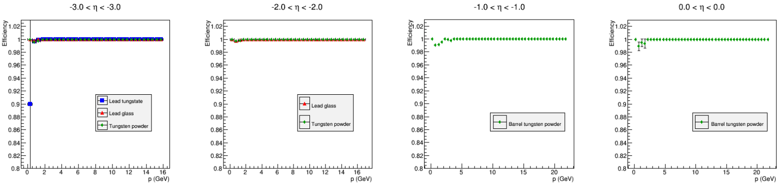

Figure 10 : Efficiency for a cut at $E/p = 0.8$

Results

Particular results: 0.9 cut

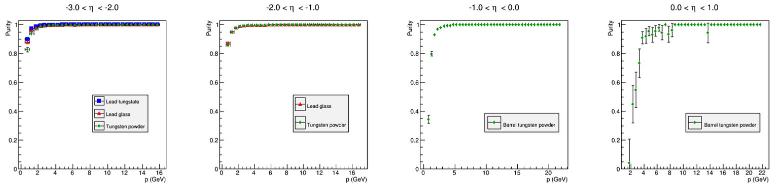

Figure 11 : Purity for a cut at $E/p = 0.9$

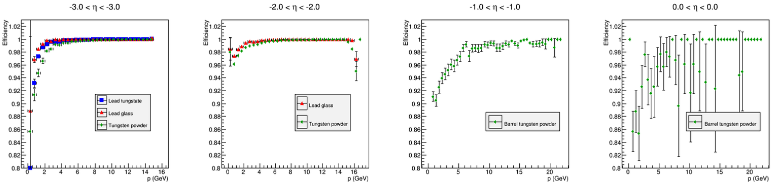

Figure 12 : Efficiency for a cut at $E/p = 0.9$

- Original separation in momentum space between electrons and hadrons: high purities by binning
- Still some momentum migration
- Graphical visualization of both purities
- Momentum *relative migration* because of smearing: $p_{rec} - p^{e}_{sim}$

Results

Particular results: momentum migration

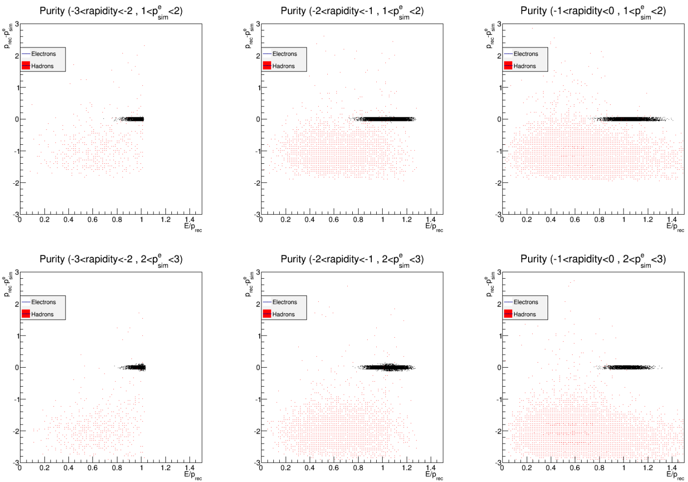

Figure 13 : Momentum migration for the tungsten powder calorimeter

Results

Particular results: momentum migration projection

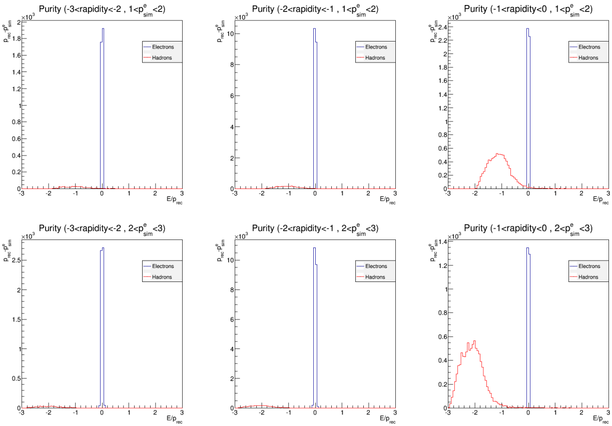

Figure 14 : Momentum migration projection for the tungsten powder calorimeter

Conclusions

- High purity, regardless of the cal
- Good resolution in momentum space
- May achieve high purities at low momenta with a restrictive cut

Acknowledgements

Elke-Caroline Aschenauer

Alexander Kiselev

Thomas Burton

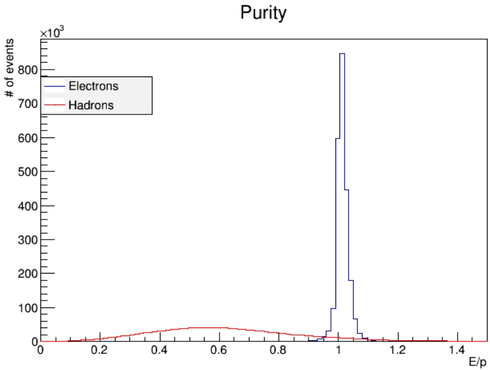

Figure 15 : Lead tungstate calorimeter, $15 GeV x 250 GeV$

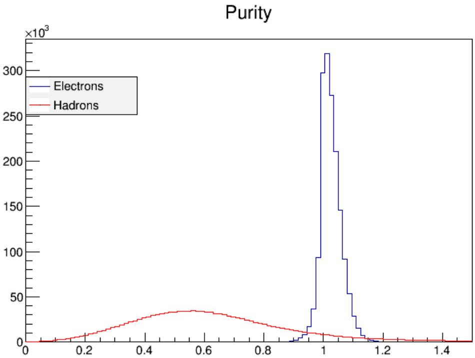

Figure 16 : Tungsten powder calorimeter, $15 GeV x 250 GeV$

Backup
Lead tungstate overlap

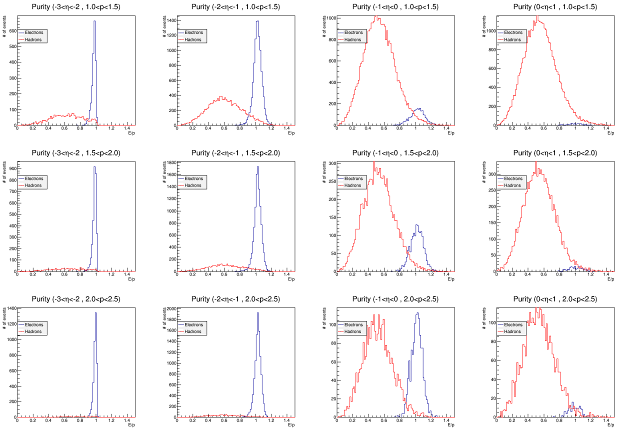

Figure 17 : Overlap for different p and η bins (lead tungstate)

Backup
Lead glass overlap

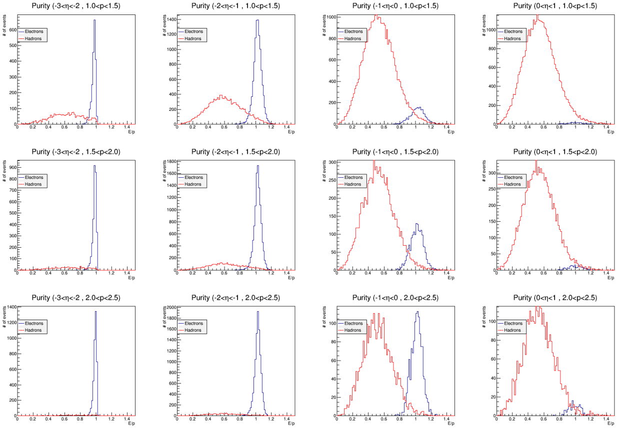

Figure 18 : Overlap for different p and η bins (lead glass)

Backup

Lead tungstate momentum migration

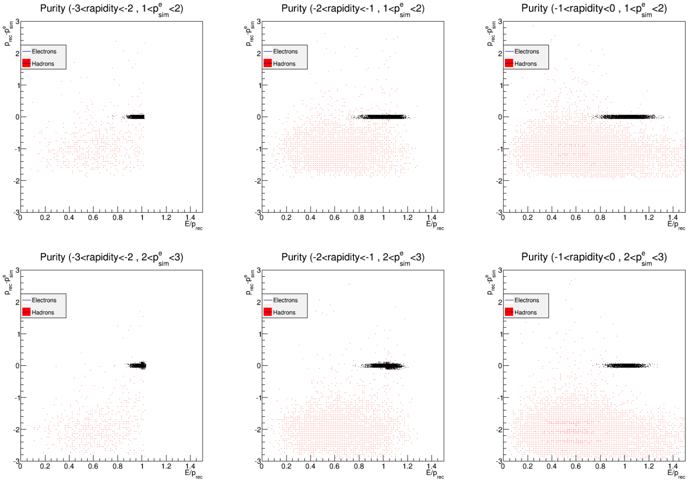

Figure 19 : Momentum migration for the lead tungstate calorimeter

Backup
Lead glass momentum migration

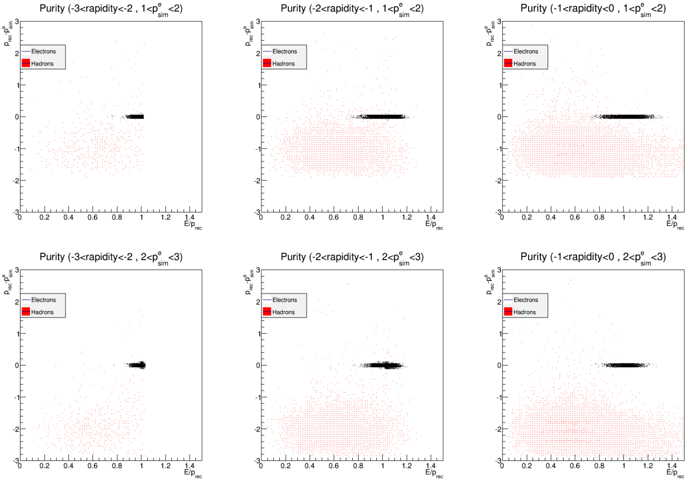

Figure 20 : Momentum migration for the lead glass calorimeter

Backup
Lead tungstate momentum migration projection

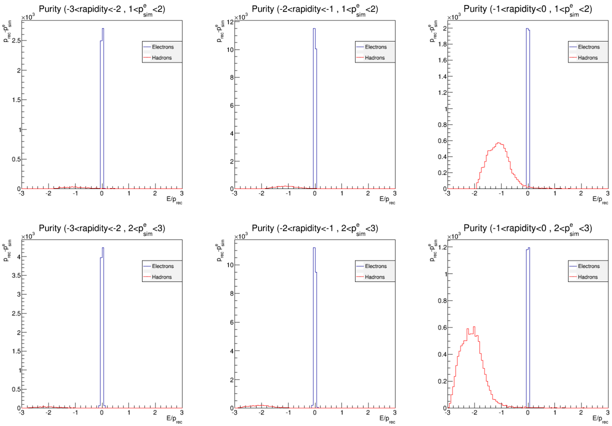

Figure 21 : Momentum migration projection for the lead tungstate calorimeter

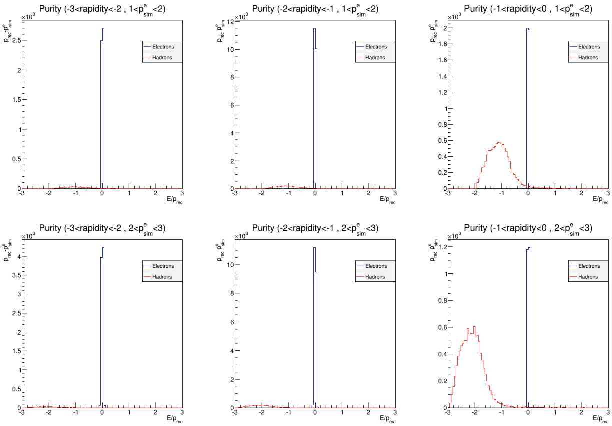

Figure 22 : Momentum migration projection for the lead glass calorimeter